electro-magnets. On imparting rotation to the armature of such an arrangement, the mechanical resistance is found to increase rapidly, to such an extent that either the driving-strap commences to slip or the insulated wires constituting the coils are heated to the extent of igniting their insulating silk covering.

It is thus possible to produce mechanically the most powerful electrical or calorific effects without the aid of steel magnets, which latter are open to the practical objection of losing their permanent magnetism in use.

III. "On the Augmentation of the Power of a Magnet by the reaction thereon of Currents induced by the Magnet itself." By CHARLES WHEATSTONE, F.R.S. Received February 14, 1867.

The magneto-electric machines which have been hitherto described are actuated either by a permanent magnet or by an electro-magnet deriving its power from a rheomotor placed in the circuit of its coil. In the present note I intend to show that an electro-magnet, if it possess at the commencement the slightest polarity, may become a powerful magnet by the gradually augmenting currents which itself originates.

The following is a description of the form and dimensions of the electro-magnet I have employed. The construction, it will be seen, is the same as that of the electro-magnetic part of Mr. Wilde's machine.

The core of the electro-magnet is formed of a plate of soft iron 15 inches in length and $\frac{1}{2}$ an inch in breadth, bent at the middle of its length into a horseshoe form. Round it is coiled in the direction of its breadth, 640 feet of insulated copper wire $\frac{1}{12}$ of an inch in diameter. The armature, which is according to Siemens's ingenious construction, consists of a rotating cylinder of soft iron $8\frac{1}{2}$ inches in length, grooved at two opposite sides so as to allow the wire to be coiled upon it longitudinally; the length of the wire thus coiled is 80 feet, and its diameter is the same as that of the electro-magnet coil.

When this electro-magnet is excited by any rheomotor the current from which is in a constant direction, during the rotation of the armature currents are generated in its coil during each semirevolution, which are alternately in opposite directions; these alternate currents may be transmitted unchanged to another part of the circuit, or by means of a rheotrope be converted to the same direction.

If now, while the circuit of the armature remains completed, the rheomotor be removed from the electro-magnet, on causing the armature to revolve, however rapidly, it will be found by the interposition of a galvanometer, or any other test, that but very slight effects take place. Though these effects become stronger in proportion to the residual magnetism left in the electro-magnet from the previous action of a current, they never attain any considerable amount.

But if the wires of the two circuits be so joined as to form a single cir-

cuit, in which the currents generated by the armature, after being changed to the same direction, act so as to increase the existing polarity of the electro-magnet, very different results will be obtained. The force required to move the machine will be far greater, showing a great increase of magnetic power in the horseshoe; and the existence of an energetic current in the wire is shown by its action on a galvanometer, by its heating 4 inches of platinum wire ·0067 in diameter, by its making a powerful electro-magnet, by its decomposing water, and by other tests.

The explanation of these effects is as follows:—The electro-magnet always retains a slight residual magnetism, and is therefore in the condition of a weak permanent magnet; the motion of the armature occasions feeble currents in alternate directions in the coils thereof, which, after being reduced to the same direction, pass into the coil of the electro-magnet in such manner as to increase the magnetism of the iron core; the magnet having thus received an accession of strength, produces in its turn more energetic currents in the coil of the armature; and these alternate actions continue until a maximum is attained, depending on the rapidity of the motion and the capacity of the electro-magnet.

If the two coils be connected in such manner that the rectified current from the coil of the armature passes into the coil of the electro-magnet in the direction which would impart a contrary magnetism to the iron core, no current is produced, and consequently there is no augmentation of magnetism.

It is easy to prove that the residual magnetism of the electro-magnet is the determining cause of these powerful effects. For this purpose it is sufficient to pass a current from a voltaic battery, a magneto-electric machine, or any other rheomotor, into the coil of the electro-magnet in either direction, and it will invariably be found that the direction of the current, however powerful it may eventually become, is in accordance with the polarity of the magnetism impressed on the iron core.

If, instead of the currents in the coil of the rotating armature being reduced to the same uniform direction, they retain their alternations, no effects, or at most very small differential ones, are produced, as no accumulation of magnetism then takes place.

I will now call attention to the fact that stronger effects are produced at the first moment of completing the combined circuit than afterwards. The machine having been put in motion, at the first moment of completing the circuit 4 inches of platina wire were made red-hot, but immediately afterwards the glow disappeared, and only about one inch of the wire could be permanently kept at a red heat. This diminution of effect was accompanied by a great increase of the resistance of the machine. The cause of the momentary strong effect was, that the machine from its acquired momentum continued its motion for a few seconds, though it required a stronger force than could be applied to maintain that motion. Each time the circuit is broken and recompleted the same effect recurs.

On bringing the primary coil of an inductorium (Ruhmkorff's coil) into the circuit formed by connecting the coils of the electro-magnet and rotating armature, no spark occurs in the secondary coil. On account of the great resistance of the circuit, which now also includes the primary coil of the inductorium, the current is not in sufficient quantity to produce any noticeable inductive effect.

A very remarkable increase of all the effects, accompanied by a diminution in the resistance of the machine, is observed when a cross wire is placed so as to divert a great portion of the current from the electro-magnet. The four inches of platinum wire, instead of flashing into redness and then disappearing, remains permanently ignited. The inductorium, which before gave no spark, now gave one a quarter of an inch in length; water was more abundantly decomposed; and all the other effects were similarly increased.

I account for this augmentation of the effects in the following way:—

Though so much of the current is diverted from the electro-magnet by the cross wire, the magnetic effect still continues to accumulate, though not to so high a degree; but the current generated by the armature, passing through the short circuit formed by the armature-branch and cross wire, experiences a far less resistance than if it had passed through the armature and electro-magnet branches; and though the electromotive force is less, the resistance having been rendered less in a much greater proportion, the resultant effect is greater.

I must observe that a certain amount of resistance in the cross wire is necessary to produce the maximum effect. If the resistance be too small, the electro-magnet does not acquire sufficient magnetism; and if it be too great, though the magnetism becomes stronger, the increase of resistance more than counterbalances its effect.

But the effects already described are far inferior to those obtained by causing them to take place in the cross wire itself. With the same application of force, 7 inches of platinum wire were made red-hot, and sparks were elicited in the inductorium $2\frac{1}{2}$ inches in length.

The force of two men was employed in these, as well as in the other experiments. When the interrupter of the primary coil was fixed, the machine was much easier to move than when it acted. For when the interrupter acted, at each moment of interruption the cross wire being, as it were, removed, the whole of the current passed through the electro-magnet, and consequently a greater amount of magnetic energy was excited, while in the intervals during which the cross wire was complete the current passed mainly through the primary coil.

The effects are much less influenced by a resistance in the electro-magnet branch than in either of the other branches.

To reduce the length of the spark in the inductorium (the primary coil of which was placed in the cross wire) to $\frac{3}{4}$ of an inch, it required the re-

sistance of $5\frac{1}{4}$ inches of the fine platinum wire in the cross wire, 5 inches in the armature-branch, and 4 feet in the electro-magnet branch.

When there was no extra resistance in either of the branches, the length of the cross wire being only about a few feet, the intensity of the current in the electro-magnet branch, compared with that in the cross wire, was as 1 : 60; and when the resistance of the primary coil of the inductorium was interposed in the cross wire, the relative intensities were as 1 : 42.

In conclusion I will mention that there is an evident analogy between the augmentation of the power of a weak magnet by means of an inductive action produced by itself, and that accumulation of power shown in the static electric machines of Holtz and others which have recently excited considerable attention, in which a very small quantity of electricity directly excited is, by a series of inductive actions, augmented so as to equal, and even exceed, the effects of the most powerful machines of the ordinary construction.

February 21, 1867.

Dr. W. A. MILLER, Treasurer and Vice-President, in the Chair.

The following communication was read:—

"A brief Account of the 'Thesaurus Siluricus,' with a few facts and inferences." By J. J. Bigsby, M.D. Communicated by Sir R. I. Murchison, Bart. Received January 28, 1867.

I have been led to attempt the preparation of a general view of Silurian life, as far as now known, by my own frequent want of such a record or muster-roll of the constituent members of this great initiatory division of palæozoic zoology,—a task which has been made pleasant by some personal knowledge of two countries rich in the earlier formations.

I have been further encouraged by the great accumulations of the last few years, through the establishment in North America and elsewhere of numerous colleges, each of them having become the centre of more or less field-work. Far more aid still has been derived from many public surveys on a tolerably liberal scale. Nor can we forget the highly meritorious and successful labours which have been, and still are, carried on by private individuals in almost every part of Europe and North America.

As this undertaking required an exactitude and a critical skill in determining species and genera according to late improvements in classification, much beyond an ordinary acquaintance with Silurian life, after my materials were put together, I obtained the very valuable aid of Mr. J. W. Salter, late Palæontologist at the London Museum of Practical Geology.

I was then, through the kindness of Sir Roderick I. Murchison, Bart., allowed to submit my manuscript to Robert Etheridge, Esq., F.R.S.E.,